Course Name: Introduction to Medical Imaging I (Elect /BIOE/COMP 485)

Time: Thursday 4:00 – 7:00 PM
Place: TBA

Course Description: This course is directed towards the senior undergraduate and graduate students who are interested in learning about medical imaging. It provides an introduction to the basic principles of various medical imaging modalities: physical basis, signal acquisition, image formation and processing. The imaging modalities that will be covered are: X-rays, CT, MRI, and Ultrasound. The course includes 2 site visits to a medical facility for a hands on experience of the various imaging modalities studied during class.

Recommended text book:

1) The Essential Physics of Medical Imaging. 3nd edition. J. Bushberg, J. A. Seibert, E. M. Leidholdt and J.M. Boone. Lippincott Williams & Wilkins (2012).

Outline:

Week 1: Review of basic mathematics and physics for radiology

- Energy, frequency, wavelength, density relationships
- Trigonometry
- Basic statistics and probability distributions
- Atomic and nuclear structure
- Decay process
- Imaging Modalities
    - Structural vs Functional
    - Transmission vs Emission imaging

Week 2: Interaction of radiation with matter

- Radiation and atomic structure
- Modes of radiation interaction with matter (particle and photons)
- Attenuation and absorption
- Radiation dose
- Radiation detectors ==> film, gas, luminescent, semiconductor
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Week 3: Image Quality

- Resolution
- Contrast
- Noise
- CNR
- SNR
- ROC
- Archival (PACS)

Week 4: X ray production and Properties:

- Theory & Fundamentals
- X-Ray tube design and rating (chest and mamography application)
- Supply Generator and control circuits
- Exposure control and timing
- Image generation
- Contrast/dose
- Equipment

Week 5: Radiography:
- Projection radiography
- Basic geometric principles
- Characteristics of screens/film
- Digital detectors (CR & DR)
- Technique factors
- Contrast and dose
- Scattered radiation

Week 6: Mammography
- Tube design
- Compression, scattered radiation, magnification
- Analog and digital mammography
- Radiation dosimetry

Week 7: Fluoroscopy.
- Fluoroscopy - basic concepts
- Performance parameters
- Feedback controls
- Radiation dose
- Specific system designs
- Clinical Application

Week 8: Computer Tomography:
- Instrumentation
- Image signal acquisition and data handling
- Image reconstruction
- Image Artifacts
- Radiation Exposure
- Clinical Applications

Week 9: Mid term Exam

Week 10: Visit to MD Anderson Medical Center (Hands on experience with X-rays, mammography, CT, image acquisition and formation. Introduction to image analysis and 3D spatial representation)

Week 11: Ultrasound Imaging

- Properties - wave propagation
- Interaction with matter (scattering, absorption, and attenuation)
- Ultrasound transducers
- Image acquisition - Modes of data acquisition
- Image resolution and sensitivity
- Image artifacts
- Blood velocity measurements - Doppler
- Clinical Applications

Week 12: MRI

- Introduction
- Net magnetization and magnetic fields
- Relaxation processes (T1, T2, T2*)
- Signal characteristics
- Pulse sequences
- Image formation (phase and frequency encoding)
- Imaging techniques (spin echo, Gradient echo, Fast imaging, Flow imaging)
- Instrumentation (Magnets, coils, computers)
- Image quality & artifacts
- Safety
- Clinical applications

Week 13: Visit to MD Anderson Medical Center (Hands on experience with US, MRI image acquisition, formation, and representation. Perform various image processing tasks on a pre-acquired US and MRI data set s

Week 14 Final Exam.